



An Early Pennsylvanian threshold for the influence of vegetation on fluvial landscapes, based on the geological record of Atlantic Canada

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Vegetation profoundly influences modern fluvial systems, depending on plant life-history strategies, tolerance to disturbance, and habitat drainage. However, direct evidence for these dynamic relationships is cryptic and has commonly been overlooked in ancient deposits. We report evidence for profound interactions between channels, in situ and transported vegetation in Lower Pennsylvanian formations of Atlantic Canada (~310 Ma), attributed to braided, meandering and fixed-channel (anastomosing) systems. Plant groups include lycopsids that preferred stable wetland settings, disturbance-tolerant calamitaleans, and deeply rooted cordaitaleans (early gymnosperms) that originated in the late Mississippian and colonised both wetland and dryland settings.

For the meandering and anastomosing channel deposits, upright vegetation was observed within channel-based bedforms and bars and on channel margins. Lycopsids and calamitalean groves colonized the channel bed and bank-attached bars during periods of reduced flow, nucleating bar growth after flow resumed. Upright lycopsids and cordaitaleans are common along channel cutbanks and are locally tilted towards the channel, implying involvement in bank stabilization. Rhizoconcretions that formed around deep cordaitalean roots may have aided bank reinforcement. Tetrapod and arthropod trackways in the channel deposits indicate a close linkage between riparian and aquatic ecosystems. In the braided systems, sediments that contain abundant cordaitalean logs constitute nearly 20% of channel deposits, and the logs form channel-base lags, fill channels up to 6 m deep, and form nuclei for shallow sandbars. Log accumulations overlain by shale lenses imply a contribution to channel avulsion. Rooted channel-sandstones containing upright trees are interpreted as vegetated islands in an island-braided system.

Anastomosing systems are abundant in these Lower Pennsylvanian formations but rare in older strata, and the multi-channel island-braided systems are the oldest yet described. The rise to prominence of these two anabranching styles, broadly coinciding with the rise of cordaitaleans, implies that fluvial landscapes had crossed a threshold from a geomorphic and biogeomorphic mode of operation into a fully ecological mode with feedback loops between vegetation and fluvial processes. Thereafter, patterns of interaction between rivers and vegetation broadly resembled those of today, with prominent riparian corridors and profound consequences for aquatic, soil and other terrestrial ecosystems. Our field observations confirm the co-evolution of river systems, vegetation and animals, and highlight a need to incorporate vegetation more fully into earth-system and landscape models.